Broadband.Money - Ask Me Anything! With Vint Cerf

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Jase Wilson
Well, hey, Broadband Money community, thanks for making time today. I think this is our biggest event yet and it's a real honor here. Our guest today doesn't need an introduction, but we're going to do a little bit of a celebration of him on this on this event, because it's - in a minimum, we want him to know that, you know, we're thankful for the wonderful contributions that he's made to humankind, and helping us unleash our full potential with what he's created, and what he's done over the years to advocate for its growth. And so it's a real honor, Vint, to get to hang out with you for a little bit of time. a

Jase Wilson
Vint Cerf, you were called by Wired Magazine, the father of the Internet. I know you'd like to sort of say co-father, with Bob Kahn, who co-wrote the paper with you, and thought through all those issues with you in 1974, and you've done so much since then, we can spend the entire hour going through your achievements, awards and accolades and

Vint Cerf
Let's not do that.

Jase Wilson
Yeah, that would be an interesting show. But we've put some information on the profile, and anybody that's curious, like you can go and look on the Internet. Which again, thank you that for that, and for making time for us.

So, Vint, it's a real honor to be with you, and I just want to say on behalf of the Broadband Money community, thank you for everything, because, you know, it's a diverse audience that we have here. It's a group of folks that are broadband builders that are out making networks and communities. You got policy folks that are working their tails off to make sure that, you know, to make the most of our public investment in broadband. We got folks that are investors in broadband networks that, you know, like to, you know, help finance projects that make a difference in communities and, you know, then we got all kinds of folks that are building things on the Internet, right is as part of the community. So, there's a diverse group in presence, and they're also state broadband directors who are about to be tasked with figuring out how to give out 75 billion bucks between the IIJA program and the Treasury program.

That's something that you, Vint, have been thinking about for decades, the Internet and how to make the most of it, and how to make sure that everybody gets a shot at it, and has access to it, and we just figured that you're a treasure trove of information, and that you have some interesting tidbits of wisdom that you could share with us, and so the one common denominator of everybody in the virtual room today is, you know, that we're all working on broadband, and we're all doing that because of what you and Bob have done all those years ago. So, thank you for being here and everything. And Vint, if you have a few words before we get rolling -- we've got a ton of questions, but we'd love to hear from you.

Vint Cerf
Well, thank you, Jase, for having me on the show. I really appreciate that. This is a group of people I care a great deal about, because what you do makes a big difference, especially if you're successful, if you actually get broadband out there in the hands of people who could use it.

When Bob and I were doing the original Internet design, we were very careful not to constrain it in any way with regard to the business model that might support it. We had in mind multiple networks with different technologies, some wireless, some wired -- fiber had not yet been made available. This is back in the late 1960s and early. But, when we did the design, we imagined that, if it was successful, that there would be new technologies coming along. And indeed, the backbone operation at the very beginning of all this was 50 kilobits a second, that was broadband back then. So, what has happened, fortunately, of course, is technology has improved and higher speeds

become available, and, as that has happened, of course new kinds of applications have been made possible, including the one that we're using right this moment, which I guarantee it would not have worked at 50 kilobits a second.

That didn't stop us from actually trying to do packetized voice and packetized video way back in the early or mid 1970s, because we were designing and building the system for use as a network for command and control, and we assumed voice video and data would be essential to that, but, of course, we didn't have much capacity to demonstrate it. Then, over time, it's gotten better. And, of course, the reason that broadband is important is that it does enable an enormous number of applications, and concurrent applications, which have turned out to be pretty important during the pandemic where we have people working from home, and kids go into school from home, and others trying to get entertained, all -- at the same time -- all making demands on the underlying networks of the Internet. And that's, of course, not just domestic but it's global as well.

But let's focus on the domestic side for just a second. As much as I wish it were not true, we still have pockets of the United States that are not well served, either at all, or with adequate capacity. And so, for all you who are on the call who care about higher speeds, this is an important discussion to pursue.

Some people have said, well, what's the definition of broadband? And I think the answer to that is, whatever speed you don't have yet, and, you know, no matter how fast it is, you'd like more. I've never seen anybody back down. I mean, after you get a gigabit -- and somebody says, well, could you do with a half a gig? The answer is no, even if you're not actually consuming all that.

So, what are we faced with right now? Well, we're certainly faced with a deficit in the rural parts of the country, generally speaking. Part of that is economic, densities are not all that high, and so if you spend a lot of money pulling fiber, for example, to provide broadband service, you may not be able to recover the cost of doing that, unless there's some way of subsidizing it, which historically has been how telephony was offered in the rural parts of the country by subsidizing urban -- the rural parts of service was subsidized by the urban services, which were of higher capacity and demand. So, we clearly have economic issues to deal with, in terms of the point broadband capability for Internet in the rural parts of the country. There are also parts of the country, even in urban areas, where service is inadequate to serve the real needs of the population. And, once again, there are issues about what the cost is, or what the price is, and can people afford it. Is it reliable enough, available, a variety of parameters, that already sit around it, that we would like to have associated with sufficient broadband service?

This raises a very important question, which I hope is in some of your minds, and that is understanding where have we got service available, where is it deployed reliably and affordably, and where is it not? That leads to some questions about measurement. I'm not going to beat the FCC 477 data, particularly, but I will say that developing better mechanisms for measuring the services that are available would be quite useful.

At Google, I was part of a team that put together something called the Measurement Lab something over a decade ago. That work is now undertaken, in partnership with the Code for Science and Society team there, plus our group at Google, plus others in the research community, who are both capturing, sharing, and analyzing performance data of the Internet, not only domestically but on a global scale.

Now, one of the things that I am concerned about and I hope you are as well is that when we try to measure what's going on in the Internet, how are people getting service, and what kind of service are they getting, we often find ourselves confused by the fact that a lot of people are getting access through Wi-Fi -- could be at home, or it could be at the library, or could be at Starbucks or something else -- but the Wi-Fi service itself has its own variable performance. And so, when you're trying to measure what performance are the users getting, you're often getting a mixture of whatever the Wi-Fi is doing plus whatever is happening at the edge of the net, which is coming in by fiber or cable or some other, maybe DSL or something else. So, deconflating the data so that we can understand, you know, where -- if there are inadequacies at all, are they derived from poorly performing and configured Wi Fi, or is it something else? Or is it a combination? So, measurement tools for debugging that are really important. Most people are not in a position to evaluate and analyze their own Internet installations.

And so we have had some preliminary discussions before this session to talk a little bit about what issues are still on our plates, and one of them is figuring out how to get a residential system set up well, so that its Wi-Fi services are well configured, and access to the Internet, through whichever provider's providing it, is also sufficient. I just had a team at my house running around trying to figure out how to reconfigure the Wi-Fi in order to make it to work better, and we honestly came to the conclusion that mesh Wi-Fi is sort of questionable, and we're gonna...

Jase Wilson
Oh.

Vint Cerf
We're going to pull a bunch of CAT6 cable around the house, and plug the hotspots into the cable, so that we don't have multi-hop inside the house, which is, in some cases, self interfering. Now, maybe some of you will say well, wait a minute, you just picked the wrong equipment, should have bought my product and not somebody else's. But I still think that it's a fair point to be made, that figuring out how to distinguish between what is the ISP level of service, and what is the user actually getting? So, measurement tools are important.

I'm chairman of the board of an organization called the Marconi Society, which is historically of course all about radio, but today, it's more about digital inclusion. Here I want to make an important point, and that is that, when we think about inclusion, it's not just access to the technology, it's knowledge of how to use it. Of course, that includes what kind of equipment should I be using? What's on the laptop? What kind of trouble might I get into? What's phishing? What's pharming? What's malware? What's the denial of service attack? What other kinds of content? What's ransomware? People need to be aware of the risk factors going online. So, as you think about delivering broadband service to people, I hope that you will be a little more expansive than just get the bits to the target with whatever low latency is possible, but think a little bit more about what else should people know in order to make good use of the service in a safe and secure way.

Two last points. I hadn't mentioned Low Earth orbiting satellites, but that's another thing that's coming, and Starlink and others are already in orbit. That will also increase people's access to the network, especially in places where it might be just out of the question for fiber, for example, the north and south pole. If you think I'm joking, actually the South Pole does need access to the Internet, because there are some fantastic physics experiments going on, one of them is called the Ice Cube, which has drilled 5000 holes into the ice, and it's watching for super high energy cosmic waves, or cosmic particles, coming to the South Pole, because they get directed there by the magnetic field of the Earth. They're gathering data of very, very high energy particles showing up, and they'd like to get the data to the physicists who want to be able to analyze it, so they need access to the Internet, even in that remote location. So, there's work to be done there.

And then I haven't mentioned, but I will mention now, the wireless ISPs, who are also a very important part of this ecosystem, where other alternatives may not be attractive economically, for example. So, there's still a lot of work to be done, and I know that the new incoming head of NTIA, Alan Davidson, who's a colleague whom I've known for decades now, is sincerely interested in getting this right, and having a real outcome where people can proudly say, I now have real access to the Internet at a speed that I can afford, and at a speed that, in fact, serves my needs. So, I hope

all of you will appreciate that I, and others who have been watching this process and hoping to facilitate it, recognize that this is a non-trivial exercise, and that every location is going to have its own set of challenges, whether they're economic or topographic or something else. Getting this right by being thoughtful and careful about getting money into the right hands is going to be an important challenge.

I'll stop there. Jase, and I'm happy to try to answer whatever questions people have. It's easy to ask the questions, and who knows where they're my answers are worth anything, but they're free of charge, so they might be worth at least that much.

Jase Wilson
Awesome, Vint. And I find it, I don't know, oddly comforting and kind of humanizing that you of all people have challenges with the Wi-Fi. You know, it's funny, right?

Vint Cerf
Well, the answer is, of course, that people implement. I did the protocol work, other people actually implement this stuff. I don't know how they implemented it because I don't have the source code in front of me. So, I have no idea what's in that little Wi-Fi router thingy., and so I'm just as mystified as everybody else, when you know, you watch it, you do the measurements, and you get high variability, and then you try to figure out where do I stick this so I get maximum capacity. So, I have sympathy for everybody else too.

Jase Wilson
Yeah, awesome, Vint. So, let's dive into the questions. And, you know, first up a special thanks to Broadband Money community member Dave Taht, who's working with the Broadband Internet Technical Advisory Group on better definitions of latency, and understanding how to, you know, get the latency out of networks, as he puts it, and among other issues, and you know, special thank you today for recommending this session and getting us in touch. So thank you, Dave, and he asked a question that's really cool. He asked, if you're elected king of the Internet, and you had the 75 billion bucks. What are the top things that you would do to make it better for everybody?

Vint Cerf
Well, the first thing I would do is make sure that some of it goes into developing better measurement tools, tools to distinguish Wi-Fi performance from the..

Jase Wilson
Nice.

Vint Cerf
... whole thing. I really think that expending some resource to make sure we get really good guidance data. And then tracking, I would like to know how well are we doing, not just right now, but into the future. Have we been able to maintain the service quality levels that we want? Now, David's pointed out, very beautifully, that buffer bloat is a serious design problem. Without jumping into too much detail, it's possible to have too much buffer in the system. The question is, how do you right size the buffer space to account for variations in speeds from the local network into the rest of the Internet? Where those two are not well matched. you can end up pouring too much stuff into a buffer, and then having the whole thing slow down, because we have to empty the buffer one way or the other. So, Dave has been very articulate about how we go about doing things like that. Others, like Van Jacobson, have been looking at end-to-end flow control, and how to avoid congestion in the middle of the net by managing things at the edges. So, I would say that that's one thing.

The second thing that I would be concerned about, is not just getting money in somebody's hands to go and build infrastructure, but let's think a little bit about how this is going to get used, and how well equipped people are to use it. So, I think some of that money needs to go into -- I don't quite want to use the word training but -- educating people about what it's like to be using the Internet in a variety of different ways different applications, and what risk factors are there and how do you keep safe in the online environment? What's good, safe Internet behavior? I would spend some of the money on that.

Then finally, I would say that, from past experience, we haven't always managed to get money into the hands of people who will actually get something built. At the state level, they really have a challenge, to receive these resources and then try to be thoughtful about where they end up, and to keep track of the progress that's being made, and to hold people's feet to the fire, so to speak, to actually build what they are supposed to do. So those things are really important, in addition.

Jase Wilson
Yeah, so you got, one is measurements and tracking, two is making sure that folks know how to use it, and they're taken care of, and they have the devices they need, and, three, is to get it into the hands of builders, and Ready and Broadband Money we call it, you know, the incumbents historically have not spent their grant money on broadband, they spend it on bonuses, buybacks, and BS...

Vint Cerf
[laughs]

Jase Wilson
... and you're absolutely right to make sure that it goes to the right folks and..

Vint Cerf
Well, we want this to work. I think we need to remember always that there are different business models that will make sense in different places, and so we shouldn't be wedded to any particular business model, and we should be adapting those models to be effective where the network is needed.

Jase Wilson
Awesome. And Vint, you know, you mentioned digital inclusion in the intro, and, you know, I'm curious, Vint, you've thought about this topic for a long time. You've seen the effects of this thing, like you built this contraption, and you invented an invention that, you know, enabled lots of other inventions upon which now society depends, and that's great and awesome, but then it's not available to everybody. So, I'm just curious, like, what does digital inclusion include, to you?

Vint Cerf
Really good question. For me, it's a very, very broad topic. It is not just access to Internet, it's not just access to the equipment that helps you use the Internet, but it also is accessibility in the sense of accommodating people who might have physical disabilities that interfere with their ability to use the technology. If you happen to be blind you can't see the screen so you need a screen reader. But the guys that do the websites need to know how the screen readers work so they can build the website HTML, so that screen reader does the right thing and it does it in an intuitive way for someone who can't see the screen, who has to experience the two dimensional thing in a serial fashion. If you happen to be deaf -- I'm not deaf, but I wear hearing aids so without them I am deaf, and I'm a big fan of captions. Google's invested heavily in making captioning possible in a variety of different contexts. But if you're designing websites, digital inclusion suggests that you accommodate people who need that kind of thing, when they can't hear. And, for some people, motor movement is hard, because maybe a Parkinson's problem or something else. Once again, you have to figure out how do I design the interface so that it accommodates someone who has those difficulties. So, when you're designing these things, at the very beginning you should be asking the question, How am I going to do this for people who might need some assistive technology to make it useful? And so, usability really is an important component. And what I discovered is, a lot of people will say, Thank God for the people who are working on accessibility because it makes it easier for me to use the applications too.

Jase Wilson
Right. I love that usability is should be included in the scope as state directors are thinking this through. It's not just about getting the right infrastructure in place, it's not just about the literacy and training. Those are important, it's also making sure that folks that don't necessarily have like the full access, for whatever circumstance, that they also have access, and that's a legitimate thing that the funds could could help with, so that's great.

Vint Cerf
Even if they didn't actually pay for it, at the very least, drawing attention to that as a desirable outcome.

Jase Wilson
Yeah, awareness.

Vint Cerf
And one can even imagine regulatory or legislative approaches. Everyone here probably is familiar with the Americans with Disabilities Act, which has been amended a couple of times. You can imagine using that as a mechanism for doubling down on assistive technology for people who are trying to make use of the Internet and need accommodation.

Jase Wilson
Great. Well, this next question. It's more of a theme of questions from the Broadband Money community that we went through and rounded up a few that are thematically similar, and it's, point blank, what advice do you have for America's 55 state and territory broadband directors, who are now on the cusp of being tasked with doling out billions of dollars to this issue. We've covered your thoughts on digital inclusion, but what do you have for them? What can you say?

Vint Cerf
Well, first of all, it's a big challenge because the first question you need to ask yourself is what is it that I don't know that I should know before I try to figure out where it is money should go? I think you should insist on getting good answers to those questions. What is there? What is in place? And, in particular, to the extent that you can get real measurement data, that would be important in order to be reassured that you actually know where additional investment is needed, and what kind of investment is needed?

I'll give you an example. There might be a situation where pulling fiber would be simply out of the question, too expensive and just not feasible. So, what when so what do you do? Well, some

people will say, Well, what about those satellites? But, it turns out there are other possibilities. For example, some of our research team has developed a point to point laser that operates at 10 to 20 gigabits a second over 10 kilometers distance, and it's about $50,000 a pair. And that's in small quantities, so in larger quantities, the price has come down. Why is that of interest? Well, if you can't pull fiber you might be able to do a point to point laser shot. And, yes, there will be questions about precipitation, potential interference at the frequencies or wavelengths that the lasers are running, but we should be looking at these middle mile kinds of alternatives. We want people to be creative about that. So that would be something that the broadband allocation decision makers would want to encourage, which is innovative solutions to the local problems that arise depending on where it is you're trying to increase capacity.

Jase Wilson
Excellent. Next question, this one I'm super curious about myself. You and Bob's 1974 white paper is to the Internet what Satoshi's 2008 white paper is to Bitcoin. So, do you think about Internet based currencies and the currencies that are enabled by the Internet? And, do you think that those Internet based currencies like Bitcoin could be more inclusive, and an enabler of financial inclusion and the new world order? And a follow up question is, Are you are you a HODLer?

Vint Cerf
First of all, no, I'm not, and second, run the other way.

Jase Wilson
Okay.

Vint Cerf
First of all, Bitcoin, because of the way they do the mining, is ridiculously expensive in terms of energy expenditure, and I don't find that at all attractive. There are other coins that don't use that, some -- instead of proof of work, proof of stake is another alternative movement. I am, let me say, skeptical about some of this. I absolutely understand that the ability to move money, if you don't have a credit card, don't have a bank account, is important, maybe both coming in your direction and being able to spend it. In India, for example, there's been a significant effort to identify members of the population so that they're known to the government, so the government can deliver value to them. There have been other situations where a cash economy has not worked well, because the cash somehow disappears before it actually gets to where it's supposed to go. It's sort of like the problem of shrinkage in the consumer business, and so having an electronic means of transfer is important. But I have to argue that while blockchain is an interesting technology, it's not the only way in which you can move money around digitally. The banking

community has been doing that for a long time. Some people will say, well, it's more expensive that way than it is this way. But, I would warn people to be very careful and thoughtful about Bitcoin technology, because it doesn't have a lot of the safeguards that the existing FinTech system has.

Jase Wilson
Okay. Good to hear. Thank you, Vint. The next question is from Graham Castleton, who built out startyourownisp.com. It's like this really cool checklist of steps that you can take to build out a WISP. So, Graham asks -- and you touched on this a little bit in your opening remarks, Vint -- How should we measure and generalize about the usability of Internet connections in communities. So, he's thinking about measurements, and he adds some context here, and says, Current measures understandably focus on throughput and costs, this often creates tension when carriers claim that they meet certain levels of service based on throughput, but Internet users continue to claim that they can't do what they need to do with their Internet connection. Are there better ways to measure and track the usability of an Internet connection?

So, almost certainly the answer is yes. Some of it, of course, relates to variability of latency, for example, but just variability of speed will be quite annoying. These kinds of conference calls, for example, suffer if you have so much variation that you have breaks in the audio or breaks in the video, so more sophisticated measurement would be helpful. What I would love to see is something beyond where we typically are today. Today, people do episodic measurements of speed, go to speedtest.net or something. You run it, but usually only run it when you're not happy with the performance, and so we get this skewed data that says everything is terrible. It's like when people go to the doctor only when they're sick, so the doctor thinks you're sick all the time, because you never show up when you're healthy. So, we should be running background tests...

Jase Wilson
Yeah.

Vint Cerf
... that are preserving of privacy, but help us understand what does this user see in terms of performance over a period of time? What are the variations, maximum, minimum average, and so on? And second, of course, can we distinguish between poor performance as a consequence of badly configured Wi-Fi, versus a poorly performing Internet access point, or Internet access to the ISP? Those are the sorts of things that I hope we could do better at, so that we can understand better how well are we serving users for a variety of different applications?

Jase Wilson
Awesome, Vint. A follow up question. This is from Dan Grossman, if you were given a blank sheet of paper and asked to design a replacement for TCP/IP, with no concern for backward interoperability -- I don't know how you wave that magic wand, but this is a great question -- because with no concern for backward interoperability, and given what we've learned over the past decades in the state of supporting technologies, what would it look like? In particular, would there be a role for persistent state in the network?

Vint Cerf
So, that's actually a very interesting question, because the design originally was to avoid persistent state in order to maximize flexibility. So, if something broke, we didn't want to have to restore a huge amount of state across a global network in order to re-establish connectivity, and so we tried to minimize the state information in each of the what we now call routers, but we called gateways back then. Without going into a really long dissertation about what would we do differently, one thing I would have done would be to have tried to design the IPv6 to be backward compatible with IPv4 somehow, and we didn't do that. I thought everybody would just implement v6 right away, because we knew that we were going to run out of room anyhow, so why not do it now and get it over with. But, it was right in the middle of the dot boom, and everybody was too busy throwing money at ISPs, and anything else that looked like it had something to do with the Internet. Everybody said, we haven't run out of v4, why bother with v6, and here we are 20, 30 years later. So, that's one thing.

Second, I would probably have wished to have put more security into the underlying protocols BGPSEC, for example, or DNSSEC, and things like that. We didn't do that, partly because we didn't have the crypto technology in hand at the time. That didn't come until later, the public key crypto. And, of course, now we've got the quantum computing coming along that's going to damage public key crypto, and so now we have new algorithms that we have to implement. If I were to start all over again, I would probably -- given what we know now and what we know in terms of technology -- I would introduce more security mechanisms at the beginning, I would introduce the larger address space, and I'm not sure that I would put much more state information in the gateways, or in the routers, any more than is already there.

The fourth thing is that software defined networks, which I used to kind of poopoo and say, Well, of course, it's all software, it's always been software, what's new? Well, the answer is you get a piece of bare metal. You have more programmability in the SDN environment than we had in the more conventional implementations, and that means you can do more to scrutinize each packet and make decisions about it. So, at least one of these designs has something like a 32 processor

pipeline, that lets you execute on the order of 4000 instructions at line speed per packet, to make a decision that works really well.

So, those all come to mind right away as things to look at, and then of course we have to be worried about congestion control. So, we have to do a better job of designing for detecting and responding to congestion. Dave Taht's bufferbloat, another issue that would need to be addressed. So, I would start over again to do those things.

I know that's the long answer, but just another little dangling participle. We've already spent the last 20 years working on an interplanetary extension of the Internet. I can tell you that the TCP/IP protocols don't work when the round trip time to Mars is 40 minutes, and so we developed a whole new suite of protocols called the Bundle protocols to deal with that. Coming back to terrestrial territory, Google developed something called QUIC, which is a multi channel protocol running over UDP, which has rapid recovery from loss of connectivity, including cryptographic recovery. It combines essentially TLS and TCP and has a few other features. It's a really nice piece of work, and it's an alternative to TCP/IP.

Jase Wilson
Wonderful. Thank you. Next question is from Sarah Lai Stirland. who's the wonderful Broadband Money editor. She's asked, What are the questions that broadband directors and their officers should ask network builders and operators when handing out grants?

Vint Cerf
Well, I think you may ask them questions that they might not be prepared to answer, or might not want to answer. But, if we could get answers about where do you actually have service and what quality is that service? Can you show me the measurements? I would really like to see what you have been delivering in the way of quality. That would be very helpful to have, but I don't know whether the ISPs, incumbents of all kinds, could be coerced into doing that. Although maybe one argument could be made, if you can't deliver that kind of data to me, I'm disinclined to offer you resources to build more Internet.

Jase Wilson
Interesting.

Vint Cerf
I don't know whether they're allowed to do that, but that might be a regulator's response to wanting to do this right.

Jase Wilson
It seems fair on the surface. Like you said, it's possible to deliver that information in the background while respecting privacy.

Vint Cerf
Well, we actually know we know that many of the ISPs are hiring companies to evaluate their performance. I'm sure that they're very interested in knowing what that actual performance is. There's an organization that I'm familiar with, called ASSIA, which does exactly that. But, the information that they gather is considered proprietary by the ISPs that have engaged their their help, and the regulators or the providers of these new funds might decide to make it a requirement to at least share that information with the parties who are making the decisions, even if it's not made public.

Jase Wilson
Makes perfect sense. Thank you. Our next question is from Robert Tse, a senior policy adviser of telecommunications at the Rural Utility Service, the RUS of USDA, and Robert asks, Where do you see broadband demand going in the future, and how do we build a broadband system with that kind of capacity?

Vint Cerf
Well, the first observation I would make is that, every time we increase the capacity of the network, somebody invents a new application to consume it. We see that now with streaming video and streaming audio and video conferencing and who knows what comes next. The second thing that we can see is a wave of Internet enabled devices, sometimes IoT or the Internet of Things, and while it may not be the case that the total capacity that's demanded by those devices is significant, even though there might be a lot of them, but the state information that might be collected could be quite modest per device. Nonetheless, there could be lots and lots of them, and making sure that the latencies are as low as possible for interactive control of those devices, or managing of the data that those devices are collecting, could be very important, and in the rural parts of the world, we're starting to see more and more effort to to do very localized agriculture. Can I figure out what I need to do for that plant at this location, as opposed to here's my 40 acres and what should I do? So, we're drip farming, or other kinds of plant-specific response to either pesticides or nutrients, and other kinds of things, localized to that plant. That may turn out to be part of the future of agriculture, and, if it is, that's a lot of data that needs to be collected and analyzed and evaluated.

Jase Wilson
Is it an IP address per corn stalk?

Vint Cerf
You heard it first.

Jase Wilson
How's that IPv6? And. on that question, Vint, another question is, in 2012 somebody asked you what's on your mind? You said, the rollout of IPv6, and you also said, net neutrality, and I'm just curious, what is on your mind 10 years later, today?

Vint Cerf
IPv6 rollout and net neutrality, among other things. Safety and security, a better educated population, to know how to defend themselves in the online environment, protection from various forms of attack, even indications and warnings, and the ability to observe activity which precedes various and sundry kinds of attack. For example, sometimes the bad guys will register a whopping pile of domain names, just alphabet soup, in order to use those as part of some denial of service attack or some phishing attack, and the domain nameregistrars and registries might be cognizant of some of that, and it might be that we can get that data in order to prepare ourselves for what might be an oncoming attack. It's kind of like the moral equivalent of the guys that look to see how many pizza boxes are outside of the Pentagon, in order to guess whether there's some big military movement coming, because they do the overnight planning and there's lots of pizza boxes.

Jase Wilson
Wow.

Vint Cerf
Yeah, you never knew that pizza boxes could tell you a lot about what's going on in the world.

Jase Wilson
I know what I'm having for dinner tonight though?

Vint Cerf
[laughs]

Jase Wilson
The next question is from Abhi Vyas and Don Walpola. I know they're the founders of the Mem protocol, which is a really fascinating new protocol that's working on reputation, and creating a sort of permanent identity that helps to move data around. They ask, Decentralized technologies make possible a world of user-owned data and decentralized identities. What are the trade offs of moving from centralized architectures where identities are coupled to applications, to a decentralized and more user-centered data models?

Vint Cerf
Well, this turns out to be a kind of a portmanteau question, and so I'm going to try to unpack it. First of all, a lot of what people assert is centralization, in some sense isn't. If you look at some of the large players in the Internet game, that's Google and Facebook and Amazon and so on, you find that they are distributed. We have data centers all over the world, and so that is a distributed architecture. It just happens to be a big architecture. So, I want to be careful not to misrepresent what's distributed and what isn't. Second, I would say there's an economy of scale, which has driven some of those large scale developments. If you if you want efficiency, sometimes you build a bigger data center, because it doesn't take any more people to run the big one as it does the little one, partly because of all the automation that's possible. So, there is an economy of scale which is driving some of this.

Vint Cerf
The identity question, though, is a really good one. And a lot of people are looking at alternatives to, you know, log in with Google, or login with Facebook, or log in with Twitter, or what have you. It would be nice if identity could be less bound to any particular application provider. I think we and others are looking at alternative architectures that would allow for identity to be recognized broadly by lots of players in the Internet ecosystem, as opposed to having an identity for this service and an identity for that one, and so on. Some people, however, will raise a big red flag and say, Well, wait a minute, I'm really uncomfortable having a single identity that could be associated with everything I do in the online environment, and there are lots of reasons why you might feel concerned about that. There's nothing wrong with having more than one identity for different purposes.

Vint Cerf
But, what you would like is that whatever identity or identities you have, are recognizable by lots of players. So, just like I may have multiple credit cards, and when I go to a particular merchant I can use any of the credit cards, generally speaking, with that merchant, or with another merchant, I have still have the ability to use different credit cards. So, we would like, for people who don't

want to have a single identity, we want to have, if they want multiple identities, they should all work. That is going to require agreement on standards by a fairly broad swath of the community, from the technical all the way up to the policy side. So, there's work going on to try to find ways of embedding such digitally authenticable identities

Jase Wilson
That's great. It sounds like Mem team should think about that too, for their project.

Another question who would win in a sci-fi poetry slam, Asimov, Herbert, Chang, or Cerf?

Vint Cerf
Well, it probably won't be me, because I haven't written poetry in a long time. I used to edit the high school poetry magazine called *The Winged Pen* at Van Nuys High School, but that was 60 years ago, and I haven't engaged very much since, so I'd probably be the last man on the totem pole for that contest.

Jase Wilson
Alright. No favorites among the others?

Vint Cerf
Not right off the bat.

Jase Wilson
Understood. This next question is from Justin Perkins, and it's a beautiful question. You've been asked countless times whether you foresaw the full scale transformation of civilization that the Internet has enabled. This question is a variation of that theme, Do you think that that transformation is mostly already complete? Or is there a bigger transformation still in store?

Vint Cerf
Well, first of all, remember that only a little over 50%, maybe almost 60%, of the world's population is theoretically online in varying degrees, and for each of the cohorts that are online, their view of the Internet varies dramatically depending on how they get access to it. A significant fraction of people get access through their mobiles, and that little display and potentially quite variable bandwidth produces one experience, and it's always through an app of some kind, as opposed to people who are on with broadband, laptops, and so on. I think we are far from having fully explored the potential applications that are available in these kinds of environments.

And, of course, there's the new buzzword, metaverse. Here again, I harbor a certain amount of skepticism about exactly how that's going to play out. Although I will admit to you that, recently, I felt forced to rethink my attitude about you know, wearing 3D goggles. My first thought about that application is that, if we were trying to do this video conferencing, and we actually had a camera on our laptops, and we were wearing our goggles, that everybody would look like Darth Vader, and nobody wants to look like Darth Vader, except maybe Darth Vader.

Jase Wilson
Well, hey.

Vint Cerf
So, then you'd have to have avatars that look like you, except because it's an avatar it could look like you plus, right? So, like, I could have hair...

Jase Wilson
Nice.

Vint Cerf
.. and you could rent clothes, digital clothes from fancy designers. So, I really am still a little bit skeptical of this metaverse idea, but I was told recently by one of my sons that, as an exercise, he wears one of the goggles, I don't remember whose, and there is a sparring partner in 3d space, and he says he gets really good exercise out of that. My first question was, Well, how do you avoid accidentally plunging through a third story window during a fight? Do you do this in a padded room? How does this work? And I guess some of the applications actually map what you're seeing into space on the floor, so that if you don't go outside of the virtual bounds, you also won't run into the wall, or plunge through the window of the real physical space that you're doing this virtual interaction in. I thought, well, that's an interesting application, and it sounds like people are feeling very, how shall I say it, comfortable in this realistic environment.

Jase Wilson
Oh, that's awesome. I love that, Vint, and what your son was describing sounds to me a little bit like The Matrix. I do have to ask a question that I've thought about since shortly after high school, and it's do the Wachowskis pay you royalties for your likeness as The Architect?

Vint Cerf
[laughs] No, and nobody asked either, and so I don't really know whether that was deliberate or whether it was just a happy accident.

Jase Wilson
There are questions.

Vint Cerf
... very much. I remember being on a Stephen Colbert show a few years ago, and he put up a picture of me, and The Architect, and asked, What's this all about? My first reaction was to ask Stephen, What makes you think you're not in the matrix? Actually, my recollection is that Stephen was a bit taken aback by that.

Jase Wilson
Yeah.

Vint Cerf
And his producer said to me before the show, you're not supposed to say anything funny, that's Stephen's job. You're just a straight man. But, when he put that picture up, I said, Man, that's a gimme, and so I asked him. I think he paused for a little while, he says, Well, I know karate.

Jase Wilson
This question is from Megan, what role do open non-proprietary protocols play in the future of the Internet? How can this increase inclusion? And, on top of that I would add, what should state directors be thinking about on that point? Is there room to fund overhauls or like some kind of provision or set aside or something, that’s not exclusive of local verticals? Like, how do we deal with that?

Vint Cerf
So, first of all, open source is a big deal, and we spend a fair amount of energy on that at Google, a number of our important inventions are open source. I have to warn you though that, as wonderful as open source is, it also has a high risk associated with it. So does the software in general, but specifically with regard to open source, a lot of people imagine that because it's open source, all the bugs have already been found.

Jase Wilson
[laughs]

Vint Cerf
Unfortunately, nobody looks, and so you end up with a mass of buggy software, and anyone here on the call who knows about the Log4j situation will appreciate how serious that could be. So, if

you're going for open source for its stimulative capacity, the ability to enable people to do things that they didn't have to program themselves, we need to pay a lot of attention to just how safe and secure that open source software actually is. So, that's an important consideration. I think, although money for broadband should not necessarily be spent on this problem, we should be finding money to spend on the problem, evaluating the safety and security of open source software, especially the software which is in broad use, widely used. Log4j was everywhere and, as a result, the consequences of the bug that was found were pretty dramatic and very widespread. So, I'm a big fan. I believe it's a highly enabling capability, but we need to make it a lot more secure or safe than it is today.

Jase Wilson
Excellent, Vint. We're getting short on on time. We know you're very busy, so we want to make the most of the remaining time. We're gonna ask one last broad question, and then we're going to go into a kind of lightning round...

Vint Cerf
Okay.

Jase Wilson
... just fire them off. You advocate for investing in resilience, reliability and redundancy. What can state broadband directors and builders learn from this? What can they do to think about this. It costs more money but it's worth it in the case of society depending on things?

Vint Cerf
Well, you put your finger exactly on the point, and that's the dependency that we have on this infrastructure. The mobile phone is a wonderful example. Keep in mind that that was released on the public by Steve Jobs in the form of the iPhone in 2007, which I remind you is only 15 years ago. In that 15 year period, we have become extraordinarily dependent on the applications that the mobile phone provides. However, if that phone isn't available, if the battery's dead, if you can't get a signal, if something else goes wrong, there are cascade effects that show up because it's a single point of failure for so many different possible applications. We should be worried about stuff like that, and the same argument to be made when the Internet goes away, and you were dependent on that, that you want to have backup. And so, finding ways of assuring that, or ensuring that consumers have, and businesses have, more than one choice for access to the Internet might turn out to be really important. But the problem is that, in the rural parts of the country, where a number of potential customers may be limited per square mile, it might not support competition. That raises the interesting question of how to achieve the redundancy that that might be

attractive. I don't have a lot of good answers there except to say that we should look at that as a as a legitimate concern as opposed to ignoring. So, looking for ways of avoiding the redundancy may turn out to be very important. It's one of the reasons that we build optical fiber in undersea cables, but we invest in satellites too.

Jase Wilson
Speaking of satellites, there's a great question, Is Starlink an answer to your 2012 vision of packets raining down from the sky?

Vint Cerf
Well, it certainly is an example of packets raining down from the sky. Of course, just recently we also have satellites raining down from the sky, which was really quite a surprise to me. For those of you who don't know, there was a coronal mass expulsion from the sun several days ago, and peak time for that to show up where we are, and we ran smack into it. It turns out that, in addition to creating all kinds of electrical interference and ionization and everything else and beautiful northern lights, it also increased the density of the atmosphere. I did not know that was part...

Jase Wilson
Really?

Vint Cerf
...of coronal mass expulsion, and because the atmosphere was denser than expected, 40 of the satellites that Elon Musk launched -- of the 49 that he launched -- actually fell out of orbit, or are on their way out of orbit, because he didn't make it..

Jase Wilson
Oof.

Vint Cerf
...and it never occurred to me that that would be a side effect of the CME. So, I think that Starlink, and the other companies like OneWeb and Kuyper, are all attempts to deliver access to the Internet from virtually any place on the globe. I welcome these efforts to the degree that they actually provide access that's affordable and reliable for people, and the affordable part is still a big question. Do we know what kind of capacity will we get? What kind of latencies will there be? And is it going to be sustainable and affordable? But, if it meets all those criteria, then it will certainly satisfy me that we have at least one works solution to the need for access to Internet from every square inch on the globe.

Jase Wilson
This next question is also from Sarah, she asks, Who should state leaders look to, if anyone, for operating models for success. She's making the point that a lot of times projects end up not working out the way that they were supposed to, or they don't work out at all, or they don't ever happen because it's the moving parts. Do you have any great models or examples?

Vint Cerf
Well, that's a really good question. It's sort of, what could possibly go wrong? The Marconi Society has set up a Broadband Coalition of people who care a lot about that and other questions. And so one thing to do would be to join the Broadband Coalition at the Marconi Society, just go to marconisociety.org, you'll be able to participate in that. I don't suggest that that coalition has all the answers at all, but that's an important question for the state policy folks to ask, Are there any work examples for example of community networks, of networks that are often built and are operated by a town or a city? There have been cases that have been successful, and there are cases that have not been successful. It's important to understand why -- when we have examples that have been successful, it's very important to know what made it successful, because it could be what made it successful doesn't work in some other locale.

Jase Wilson
Yup.

Vint Cerf
So again, we want to be open to a variety of different architectures and business models for expanding Internet access. I would not turn solely to incumbents for a solution. I would I would want to open the aperture to a variety of possibilities. But certainly, when somebody proposes to do something, you might ask the question, Have you ever done this before? Do you have any work examples? Can we see what you'd done?

Jase Wilson
Yes.

Vint Cerf
To gain confidence that the proposals are realistic.

Jase Wilson
Amazing, Vint. That's a wonderful answer. Lightning round time. Next question is from Mike at ready.net, and those are the makers of fine tools for ISPs to grow their business. He asks, Are you why we call it surfing the Internet?

Vint Cerf
[laughs] So the answer is, that's a wonderful delicious coincidence, but the term was coined by a gal who was writing about surfing the ocean of information, and the fact that my last name sounds that way, but it's not spelled that way, is just a delicious coincidence.

Jase Wilson
Okay, wonderful. I have a question for you. Was Asimov's *The Last Question* an inspiration for you and Bob, as you sat down to write what essentially would lead us to the planetary AC?

Vint Cerf
I'm sorry, ask the question one more time, Jase. I don't think I understood it.

Jase Wilson
Was Asimov's The Last Question?

Vint Cerf
You know, I am a huge Asimov fan, and particularly Hari Seldon, and psychohistory, and all that wonderful stuff in the Foundation series, to say nothing of all the other stuff he writes, robots and everything else. But no, it wasn't Asimov, really, that grabbed my attention there. I think it was, honestly, the success of the ARPANET project, which was a single network experiment in packet switching and in interconnecting heterogeneous computers. The success of that project, which was funded by ARPA, and that Bob Kahn and I, and Steve Crocker and others -- and there's a long list of people -- had a lot to do with, the real vision came from Douglas Engelbart and JCR Licklider. Both of them saw computers as things that would augment human capability, that would become partners in our day to day work. AIf there was any vision from my point of view, and I can't speak for Bob, it was those ideas that I found very compelling, which made it so exciting to try to work on a technology that might allow us to test their predictions or test their theories. And so, we're still testing, we're still discovering artificial intelligence and machine learning, we're still discovering how people interacting with each other, with the death of distance, is pretty amazing.

Now, there is one unsolved problem. Even though we've collapsed distance with the Internet, we haven't figured out what to do about time zones. That's our next challenge is how to figure out

how to collapse time zones. Of course, easy answer to that is, why don't you just get together physically in the same place?

Jase Wilson
Right. So 2021.

Vint Cerf
You're telling me.

Jase Wilson
Yeah, Vint, thank you again, we got two last questions, if you have just 30 more seconds.

Vint Cerf
Go ahead.

Jase Wilson
Cab, Zin, Pinot, Merlot, Gamay, like what's..

Vint Cerf
okay, so..

Jase Wilson
You're a huge wine guy?

Vint Cerf
Well, I'm a I'm a huge Cab and Chardonnay fan, especially White Burgundy and Napa Valley Cabs, but my wife and I are both become increasingly fond of Viognier, which is very much lighter white wine than the Chard, and we've also become fans of Pinot Noir. So while we were out in Oregon, we shipped 24 cases of Pinot Noir back home...

Jase Wilson
Oh.

Vint Cerf
...so we have a wall full of Pinot Noir to go through, in addition to all of the other things we have from about a dozen countries around the world.

Jase Wilson
Beautiful. Vint, one last question. Are you the protagonist who solved the off by one error, in Was the Night Before Startup?

Vint Cerf
[laughs] One of my favorite RFCs. Actually, yes. When I wrote that I was thinking of a particular off by one bug that both bit me, and eventually I was able to solve, so yes, that was me.

Jase Wilson
Nice work. Vint, this has been amazing. On behalf of everybody in the broadband.money community, thank you again for everything that you've done, for creating this space, andall that you continue to do to make it better and better and better, and I hope for folks that are listening, you got something out of this. I know I certainly did. But, Vint, it's been a real honor, and we appreciate you, so thank you.

Vint Cerf
Well, thank you very much, Jason. So, all of you out there working on this problem, work hard, solve the problem, get that Internet out there so everyone can benefit. Thank you for your hard work.

See you on the 'Net.